(12) UK Patent Application (19) GB (11) 2 217 254 (13) A

(43) Date of A publication 25.10.1989

(21) Application No 8808752.3

(22) Date of filing 13.04.1988

(71) Applicant
Metal Box P L C

(Incorporated in the United Kingdom)

Queens House, Forbury Road, Reading, Berkshire, RG1 3JH, United Kingdom

(72) Inventor
Malcolm George Collins

(74) Agent and/or Address for Service
Robert Anthony Owen
Metal Box PLC, Denchworth Road, Wantage, Oxfordshire, OX12 9BP, United Kingdom

(51) INT CL⁴
B29C 65/06

(52) UK CL (Edition J)
B5K K3A10

(56) Documents cited
None

(58) Field of search
UK CL (Edition J) B5K
INT CL⁴ B29C

(54) **Method and apparatus for spin welding**

(57) A method of spin welding an annular weld zone of a first component to a complimentary annular surface of a second component, in which a tool (Fig. 3) for holding or driving one of the components has centring means 31 to centre a component 17, 18 on the rotational axis, a thrust surface 32 adapted to engage a margin of said component, and a plurality of spikes 33 protruding from the thrust surface to penetrate the margin of the component when the thrust surface 32 is pressed onto the margin. The benefit is that no drive webs or holding dogs are needed. The annular weld zones of the components may be profiled (Fig. 9) to define a weld land L and void t flanked by complimentary annular projections B and troughs A to seal the weld zone against melt leakage.

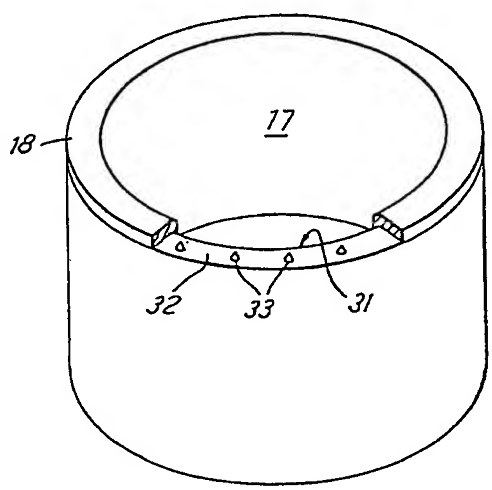

FIG.3

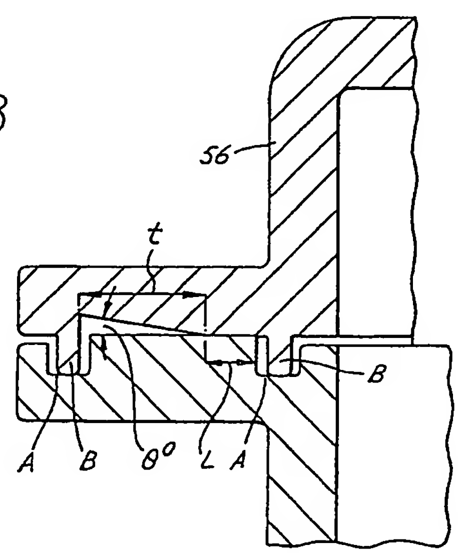

FIG.9

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

2217254

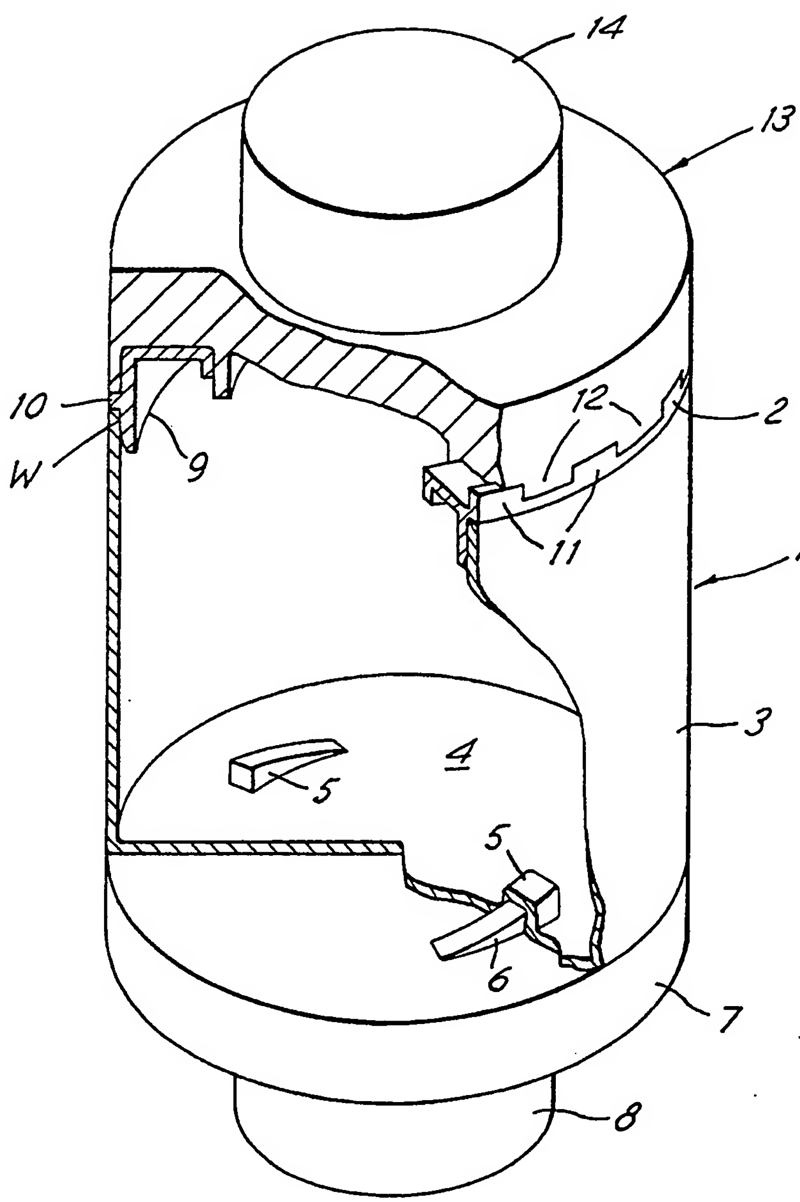

FIG.1

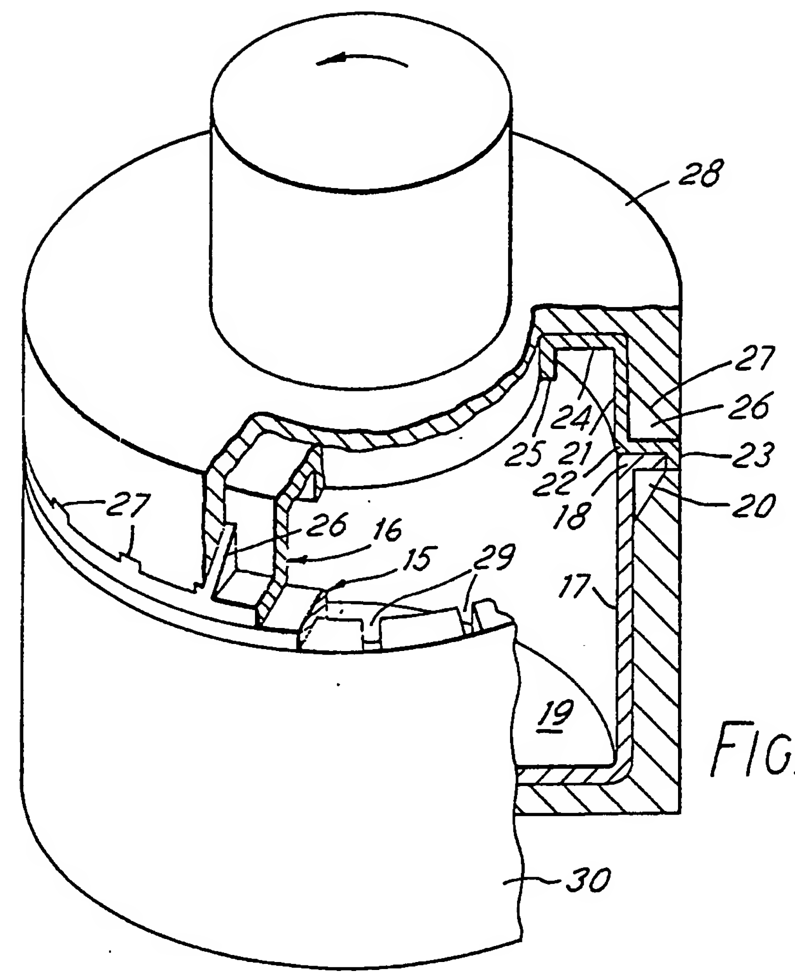

FIG.2

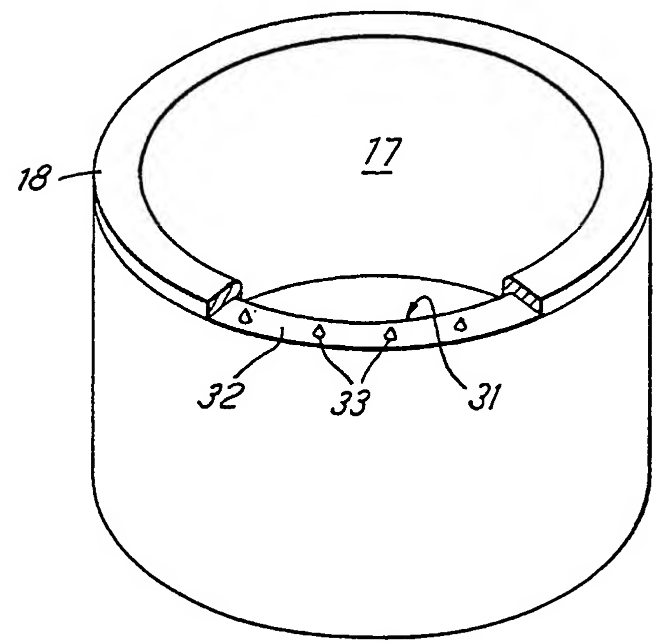

FIG.3

2217254

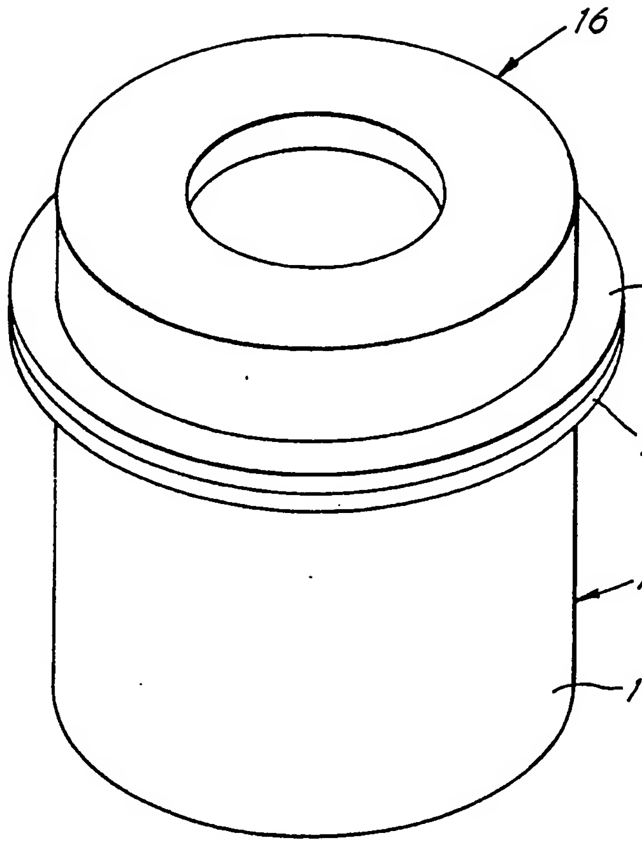

FIG. 4

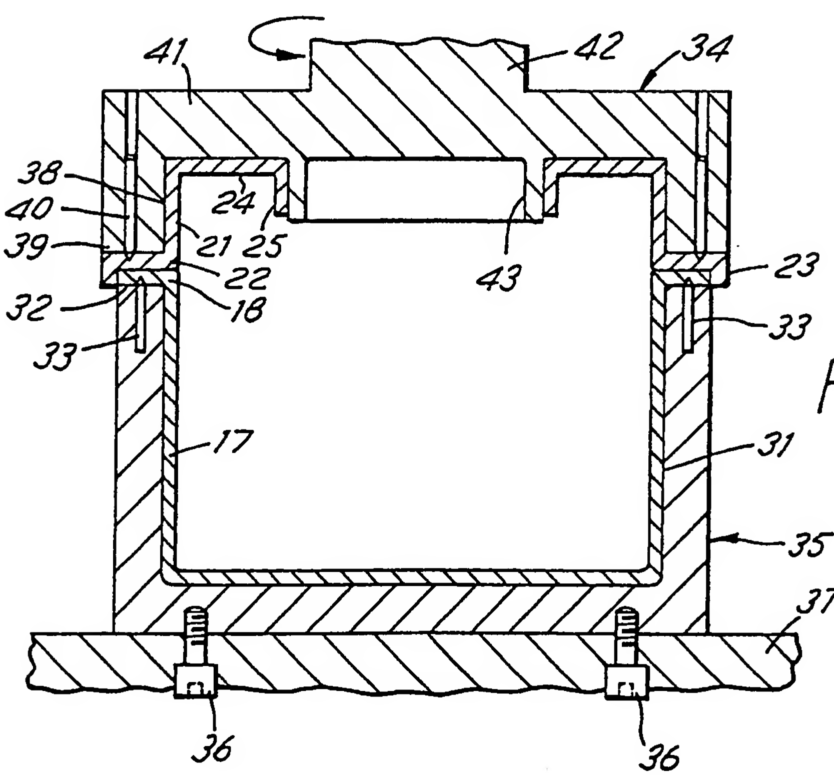

FIG. 5

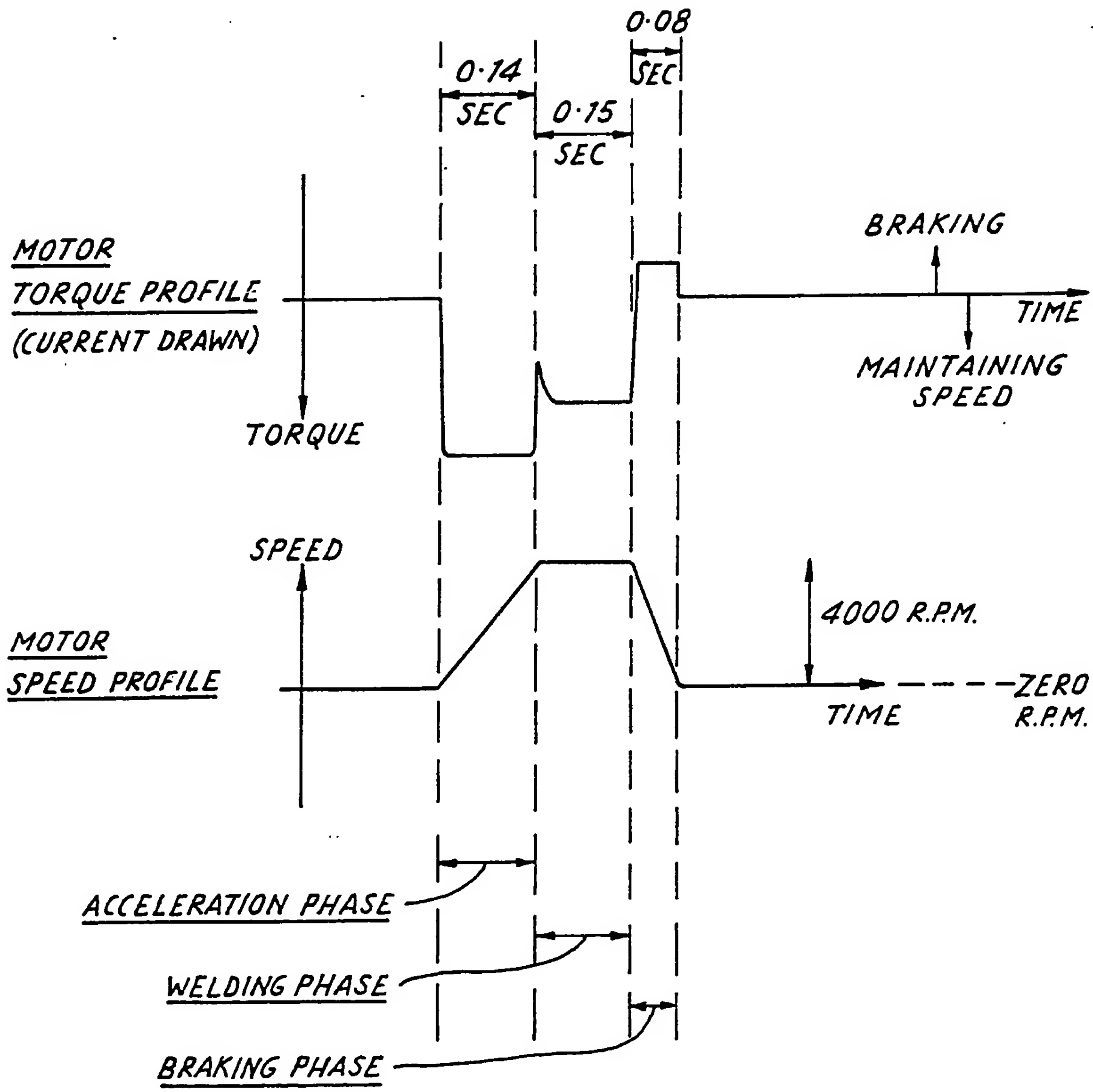
0·08
SEC
0·14
SEC
0·15
SEC
MOTOR
TORQUE PROFILE
(CURRENT DRAWN)
TORQUE
BRAKING
TIME
MAINTAINING
SPEED
SPEED
MOTOR
SPEED PROFILE
4000 R.P.M.
TIME
ZERO
R.P.M.
ACCELERATION PHASE
WELDING PHASE
BRAKING PHASE

FIG. 6

2217254

5/5

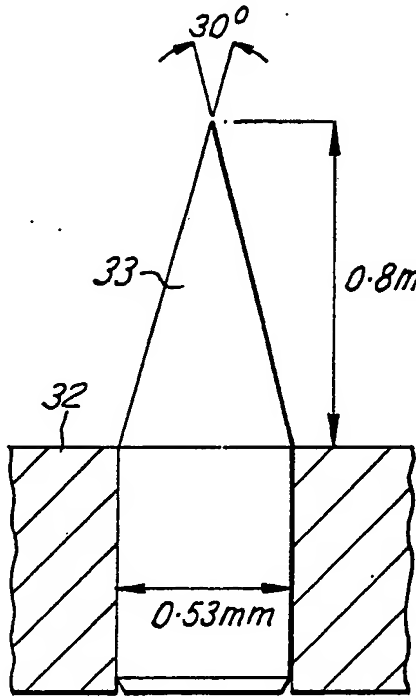

FIG.7

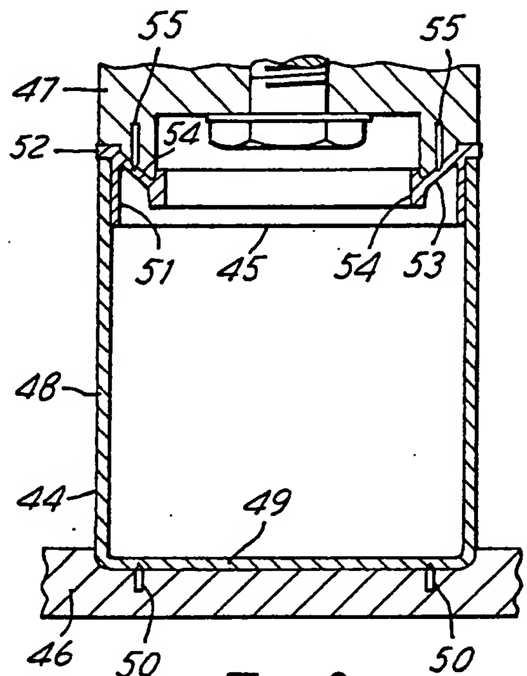

FIG.8

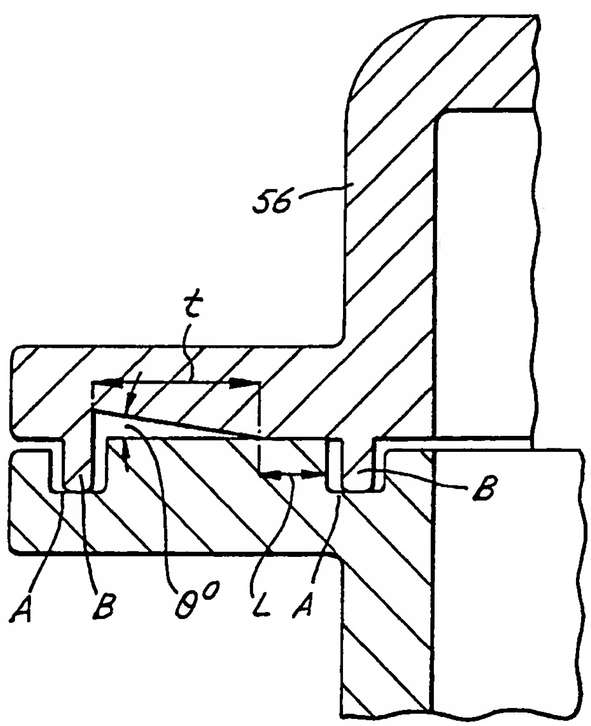

FIG.9

2217254 CASE A4003

"METHOD AND APPARATUS FOR SPIN WELDING"

This invention relates to a method and apparatus for spin welding and more particularly but not exclusively to a tool for holding or driving a first component of plastics material during spin welding to a second component of plastics material.

It is well known to mould projections or slots in each component for cooperation with complimentary shaped slots or projections in holding or driving tools so that during driven rotation of one component the other component is held stationary.

The slots or projections have to be robust enough to survive any snatching forces arising during take up of the rotational drive and the sustained forces arising during spin welding. Thereafter the slots or projections are often a feature redundant to the article made and remain a source of extra expense in cost of plastics material and possibly an unsightly feature of the assembled article. For instance, pegs or projections moulded in blind ended cavities may be inadequately fed and so exhibit sink marks.

One objective of this invention is to provide a method of spin welding which does not require components to have features dedicated solely to receive the drive or holding force.

Another objective is to provide apparatus for driving or holding a component during spin welding by means of a tool which creates its own drive resistant features and leaves little or no visible witness on the welded components.

In a first aspect this invention provides a method of spin welding an annular weld zone of a first component to a complimentary annular surface of a second component; providing (a) a first tool having a centring surface to cooperate with a surface of the first component to hold said first component central upon the axis of rotation of

said first tool; a thrust surface arranged for axial alignment with said first annular weld zone; and a plurality of spikes projecting from the thrust surface; (b) a second tool having means to hold the other component stationary against rotation, in axial alignment with said first tool, and supported against thrust in an axial direction; and (c) means to effect relative motion as between said first and second tools in an axial direction centring a first component on said first tool; holding said second component in said second tool; reducing the distance between said first and second tools to press said annular weld zone of the first component onto said complimentary annular surface of said second component so that the spikes are driven into a surface of the first component; effecting relative rotation as between said first component and said second component to spin weld said annular weld zone to said complimentary surface; and separating said first tool from said second tool to release the welded components.

The annular weld zone and annular surface may be provided with a cooperating labyrinth of annular projections and troughs to trap any melt at the weld zone in addition to support annular profile features that assist in the creation of a fused weld using the minimum energy input.

In a second aspect this invention provides a tool for holding or driving one of a pair of components to be united by spin welding, said tool comprising a centring surface adapted to centre a component on the rotational axis of the tool; a thrust surface adapted to deliver an axial thrust onto said component; and a plurality of spikes upstanding from said thrust surface to penetrate said component when the thrust surface is pressed onto said component.

In one embodiment the tool has a thrust surface in the form of a peripheral flat annulus adapted to press upon an external flange of a component; and in this embodiment the centring surface is a cavity in the tool which holds the body of the component snugly on the rotational axis.

In another embodiment the tool has a thrust surface in the form of a plug which is enterable into a recess in the component so an end wall delivers thrust and a side wall of the plug acts as a centring surface.

The tool may either have means for holding it stationary against rotation of one of the components or alternatively the tool may have means for connection to means to rotate it.

In one embodiment described a first spiked tool is used to rotate a first component while a second spiked tool is used to hold the complimentary second component stationary.

The benefits of these spiked tools are that

a) the thrust surface holds the component in the desired geometrical form during welding, in contrast to twisting forces that can arise at prior art drive dogs; and

b) the spikes leave little or no witness marks to spoil the appearance of the welded components.

Various embodiments will now be described by way of example and with reference to the accompanying drawings in which:-

Fig.1 is a perspective side view of spin welding tools and a pair of components cut away to show prior art devices for holding or driving one component relative to the other;

Fig.2 is a perspective side view of spin welding tools and a pair of components each of which has a lateral flange extending between the tools and webs for holding or driving as is also known in the prior art;

Fig.3 is a perspective view of a tool according to the invention and a component located within the tool and cut away to show drive/holding spikes;

Fig.4 is a perspective sketch of the component of Fig.3 united with a lid to make a container;

Fig.5 is a sectioned side view of first and second tools during spin welding of a pair of components;

Fig.6 is a graph of motor torque and associated motor speed v time;

Fig.7 is a sectioned side view of one of the spikes

Fig.8 is a sectioned side view of spin welding apparatus in which the centring surface of one of the tools is a plug; and

Fig.9 is a fragmentary section through flanges modified to trap flash.

In Fig.1 a container comprises a body 1 connected to a collar 2 by an annular weld "W" created by spin welding.

The body 1 has a side wall 3 closed at one end by a bottom wall 4 which has two hollow ramp-like structures 5 which accommodate holding blocks 6 of a lower tool 7. The lower tool 7 is held stationary by its shank 8.

The collar 2 has a cylindrical plug wall 9 which enters the top of the side wall 3 until external flange 10 abuts the top of the side wall. The plug wall 9 extends, in an axial direction, beyond the radial flange 10 to define castellations 11 which receive drive dogs 12 of upper tool 13 which is rotated by means of its shank 14 by a drive system (not shown) to cause frictional heating of the interfacial weld zones of collar 2 and side wall 3 as the collar rotates upon the side wall 3 of the body. It will be readily understood that engagement of the drive dogs 12 with the castellations 11 of the collar, and engagement of the holding blocks 6 with the hollow ramp-like structures 5 is sudden and potentially

destructive. Furthermore the appearance of the welded container may be spoiled by the castellations and ramp-like structures, particularly if they are damaged.

In Fig.2 another container has a body 15 and a collar 16. The body 15 comprises a side wall 17 terminating at an upper end in an outwardly directed flange 18 and at the other in a bottom wall 19. The flange 18 is supported by a plurality of buttress webs 20 rooted in the side wall 17. The collar 16 further comprises an annular end wall 24 having an internal flange 25 to define the mouth of the container. A plurality of buttress shaped webs 26 extend from the collar flange 22 to the cylindrical wall 21 of the collar.

In Fig.2 recesses 27 in a driven top tool 28 receives the webs 26 of the collar for the purpose of delivering rotational drive while recesses 29 in a stationary bottom tool receive webs of the body to hold the body 15 stationary during spin welding. Once again, the appearance of the welded body is at risk of being spoiled if the webs 20, 26 become damaged, and more seriously damaged webs may fail to deliver the necessary torque to achieve a sound weld. Damage to webs or castellations may be reduced to a minimum by control of application of axial pressure during a period of slow spin rotation while the drive and holding tools engage with driving and holding webs or castellations but at a cost of machine time.

Fig.3 shows a tool for holding or driving one of a pair of components to be united by spin welding. The tool comprises a centring surface 31 in which the side wall 17 of a component fits snugly to be held centrally on a rotational axis. An annular thrust surface 32 of the tool fits against the underside of a flange 18 of the component to support the flange 18 in correct shape. In Fig.3 the flange is cut away to reveal four of the twelve equispaced spikes 33, rooted in the thrust surface, which protrude to

penetrate the underside of the flange of the component. A benefit from this type of tool is that the flange is held flat so that the weld zone on the opposite surface of the flange is in good shape to frictionally engage a complimentary weld zone.

The tool of Fig.3 may be used to make the container shown in Fig.4. The container has a body and a collar as discussed with reference to Fig.2 so like parts are denoted by the same reference numbers as used in Fig.2, namely, a body 15 has a side wall 17 terminating in an outwardly directed flange 18 and the collar 16 also terminates in an outwardly directed flange 22. The peripheral skirt 23 of the collar flange 22 (of Figs. 3 and 5) is not essential and is omitted from Fig.4 so that the weld is visible. However it will be noticed that the container of Fig.4 has no visible driving webs, castellations or the like.

The apparatus shown in Fig.5 comprises a top tool 34 and a bottom tool 35, the bottom tool being fixed by studs 36 to a base plate 37 so that it remains stationary. As the bottom tool 35 and the component drawn therein are identical to the tool and component shown in Fig.3 the same part numbers are used to denote like parts.

The top tool 34 comprises a cylindrical wall 38, the interior surface of which acts as a first centring means and an annular end surface 39 which acts as a thrust surface from which protrude a plurality of spikes one of which is denoted 40. We have found that steel gramophone needles are suitable for use as spikes because they have a suitable point to penetrate plastics materials on a shank long enough for firm rooting in the cylindrical wall 38. An end wall 41 spans the cylindrical wall and a shank 42 centrally placed on the end wall extends upwardly to permit fixing to rotational drive means (not shown). A hollow plug 43 extends from the end wall into the space

defined by the cylindrical wall 38 to act as a second centring means by entering the mouth of a collar defined by the flange 25. If desired, the plug may be made long enough to centre the collar before the pins penetrate the flange 22 of the plastics collar. In any case the plug, end wall and interior surface of the cylindrical wall all serve to keep the collar in correct shape before the torsion forces of spin welding are applied.

The method of using the tools of Fig.5 comprises the steps of spacing the tools of Fig.5, placing the plastics body component in the bottom tool so its side wall 17 is centred by the internal centring surface 31 and its flange 18 rests on the spikes 33 upstanding from thrust surface 32.

A plastics collar moulding is placed in the top tool 34 so that a side wall of the collar is centred in the cylindrical wall and the spikes upstanding from the thrust surface.

The top tool 34 is then moved in an axial direction towards the bottom tool 35 so that the flanges 22, 18 are brought into frictional engagement; the spikes 40 penetrate flange 22 and the spikes 33 penetrate the body flange 18 so that the body is held stationary by lower tool 35 and the collar is spiked on the top tool ready for rotation.

The top tool 34 is then rotated so that frictional forces at the interface of flanges 22, 18 generate heat to spin weld the collar to the body. Thereafter rotation of the top tool is promptly stopped and the tools are moved apart to release the welded container.

EXAMPLE:-

A collar moulded from polypropylene to have a peripheral flange 2.5 mm wide and overall diameter 100 mm was welded to a flange 2.5 mm wide and overall diameter 100 mm of a hollow body. The collar flange had a

peripheral skirt 23 (as shown in Figs. 3 and 5) which served to contain melt arising during spin welding and prevent unsightly flash emerging to spoil the appearance of the finished weld.

The driven tool was rotated at 4000 rpm using a low power servo motor capable of delivering only 24 Nm torque. A fully fused weld was made in a total time of 0.37 seconds using an axial (thrust) load of about 150N.

The actual speed and torque traces are shown in Fig.6 where it can be seen that the motor required about 0.14 sec. to accelerate the tooling and driven component up to 4000 rpm where it remained for a further 0.15 sec before being braked to a standstill in about 0.08 sec.

The maximum motor torque was exerted during the acceleration phase but thereafter a lower torque of 16 Nm was exerted on the component simply to maintain the welding speed. A reverse torque of only 9.5 Nm was required to effect the rapid braking required because of the assistance afforded by the visco-elastic drag of the molten polymer of the weld zone.

These torques were amply transmitted to the upper component and resisted by the lower component by means of twelve equispaced spiked steel projections on each of the two respective pieces of tooling. The axial length of each conical projection was 0.8 mm and the diameter of each at its root about 0.53 mm as shown in Fig.7.

The same tooling was successfully used to weld these components using axial loads as low as 10N although naturally the weld time had to be considerably increased to create sufficient melt to achieve integral welds. In other words, although high axial loads are beneficial insofar as they are more likely to encourage the positive engagement of spikes with components, as well as facilitate short weld time, modest axial loads can also be successfully used if required.

In all cases the witness marks left by the penetrating spikes are extremely difficult to detect visually so that the finished appearance of the welded container is pleasing to the eye and suitable for most commercial applications where such thermoplastic components are required to be spin-welded together.

Fig.7 shows one of the spikes 33, 40 used in the example described. The included angle of the point of the spike was 30° and the extent of protrusion beyond the thrust surface 32 was 0.8 mm. A shank length of about 15 mm was rooted in the support surface, the shank diameter being 0.53 mm. It was surprising that only twelve of these small spikes on each tool were so effective in holding/driving the components and left impressions which were hardly visible.

In Fig.8, a container comprising a moulded plastics body 44 and a plug fit ring 45 is shown to be held between a bottom tool 46 which holds the body stationary while a top tool 47 rotates the collar to spin weld the ring to the body.

The container body 44 is typically moulded in polypropylene to have a side wall 48 and a bottom wall 49. The bottom wall 49 is centred on the spin welding axis by seating in a recess in the bottom tool 46. An array of spikes 50 protrude from the bottom surface of the recess to arrest rotation of the body in the recess by penetrating the bottom of the body.

The ring 45 has a cylindrical plug wall 51 which is a push fit into the side wall of the body. A peripheral flange 52 prevents the plug wall entering too far into the side wall 48 of the body. A frustoconical wall 53 extends radially inwards and axially downwards from the flange to terminate in an annulus 54 which defines the mouth of the ring. The top tool 47 has an end surface 54 which fits upon the flange 52 and frustoconical surface 54 of the

ring to act not only as a centring means but also as a thrust surface to impose an axial load (or top pressure). A plurality of spikes 55 protrude from the end surface 54 of the top tool to penetrate the frustoconical wall 54 to deliver a torsional drive as the top tool is rotated to effect a spin weld between the plug wall 51 of the ring and side wall 48.

If however, it is desired to only weld the flange to the end of the side wall of the body the spikes could usefully protrude into the flange of the ring instead of the frustoconical surface.

The flanged welding area, such as shown in Figs. 2,3 and 5 are of simplified design and indicate one flat surface being pressed against the other during welding. In practice this does not work well since molten polymer produced at the interface tends to be readily displaced to form both internal and external "flash" to leave an essentially "dry" interface. Mechanical means for preventing this loss of melt can sometimes be effective but in the case of an annular flange where flash is unsightly an attractive integral weld can be achieved using moulded features to both to retain the melt within defined limits and encourage interfacial fusion.

An example of how this can be achieved using moulded components is shown in Fig.9 where components 56 and 57 have cooperating features. Component 56 has annular projections,B, which fit within the annular troughs, A, of component 57 when the two components touch at the melt-generating "land area", L. Component 56 is profiled such that a wedge-shaped annular separation, of width "t" exists between the two components when assembled prior to welding and during the spin welding operation, melt-generated at L fuses into this wedge angle denoted 0° and fuses the two components together.

The outermost projection B^1 and trough prevent the melt from emerging at the periphery and the innermost projection B and trough likewise prevents melt from flowing beyond the boundary walls of the mating components.

These projections and troughs not only act to limit the radial flow of melt in the aesthetic sense but actually effect a physical barrier against the loss of melt which would otherwise occur to the catastrophic detriment of weld integrity. This is particularly true of semi-crystalline polymers such as polypropylene which has a very low melt viscosity, but equally applies to polyethylenes and nylons for example.

The angle 0°of the annular wedge portion, is preferably in the order of 3°to 5° and the width "t" of the separation zone is about equal to "L", the width of the contact land.

Whilst the invention has been described with reference to components having peripheral flanges the invention is not limited thereto. For instance a pair of hemispherical components of sufficient thickness could be welded edge to edge to make a ball for a ball valve.

CLAIMS :-

1. Apparatus for spin welding having a tool for holding or driving one of a pair of components to be united by spin welding said tool comprising centring means to centre the component, a thrust surface adapted to engage a margin of said component and a plurality of spikes upstanding from said thrust surface to engage with a margin of the component when the thrust surface is pressed onto the margin.

2. Apparatus according to claim 1, wherein the tool has means to hold it stationary against the rotational force of spin welding.

3. Apparatus according to claim 1 wherein the tool has means to connect with driving means for rotation.

4. Apparatus comprising a first tool according to claim 2 and a second tool according to claim 3 wherein the end wall of said first tool is axially aligned with the end wall of said second tool so that relative motion as between the tools along the rotation axis of spin welding, clamps upon respective peripheral flanges of components placed therebetween.

5. Apparatus according to any preceding claim, wherein each spike has a frustoconical extremity upstanding from the end face.

6. Apparatus according to claim 5, wherein the frustoconical portion of each spike has an included angle of 30°.

7. A method of spin welding an annular weld zone of a first component to a complimentary annular surface of a second component; providing (a) a first tool having a centring surface to cooperate with a surface of the first component to hold said first component central upon the axis of rotation of said first tool; a thrust surface arranged for axial alignment with said first annular weld zone; and a plurality of spikes projecting from the thrust

surface; (b) a second tool having means to hold the other component stationary against rotation, in axial alignment with said axial direction; and (c) means to effect relative motion as between said first and second tools in an axial direction centring a first component on the first tool; holding said second component in said second tool; reducing the distance between said first and second tools to press said annular weld zone of the first component onto said complimentary annular surface of said second component so that the spikes are driven into a surface of the first component; effecting relative rotation as between said first component and said second component to spin weld said annular weld zone to said complimentary surface; and separating said first tool from said second tool to release the welded components.

8. A method according to claim 7, wherein each component has a peripheral flange extending laterally of a side wall portion so that the side wall portions of both components are held in axial alignment by a cavity in each tool and the flanges are pressed together by cooperation of the end walls of each tool.

9. A method according to claim 7 or claim 8, whereby a peripheral flange of a polypropylene ring is spin welded to a complementary flange of a polypropylene body to make a container wherein an axial load of between 10 N and 300N is applied to hold the flanges together and a spin welding torque in the range of 5 N_m to 120 N_m is applied at a spin speed in the range of 1000 rpm to 6000 rpm to achieve a weld.

10. A method according to claim 7 wherein the annular weld zone of the first component is provided with a flat land L; is frustoconical portion extending laterally from the flat land; a first annular projection projecting from

the inner periphery of the land and a second annular projection concentric with said first annular projection and projecting from the outer periphery of the frustoconical portion; and the annular surface of the second component is provided with concentric annular troughs dimensioned to receive the annular projections of the first component B, the projections being of a height to make ring seals on the bottom surfaces of the respective troughs.

11. A pair of components each of which has an annular surface shaped to permit joining, one to the other, by spin welding characterised in that
a first component has an annular surface comprising a first annular projection, a flat annular land extending in a radial direction from the root of the inner annular projection, an annular surface extending at an acute angle from the flat land to a second annular projection concentric with the first annular projection; a second component has an annular surface comprising a first annular trough, a flat annulus extending radially from the trough to a second annular trough concentric with the first trough, such that when the annular surfaces are assembled together the land of the first component contacts the flat annulus of the second component and the annular projections of the first component reach the bottom of their respective troughs on the second component.

12. A pair of components according to claim 11, characterised in that the inclined annular surface of the first component is nearer the external periphery of the component than is the land.

13. A pair of components according to claim 11 or claim 12, wherein the projections are narrower than the trough widths.

14. Apparatus for spin welding substantially as hereinbefore described and shown in Figs. 3,5, 7 and 8 of the accompanying drawings.

15. A method for spin welding substantially as hereinbefore described with reference to Figs. 3 to 9 of the accompanying drawings.

Published 1989 at The Patent Office, State House, 66/71 High Holborn, London WC1R 4TP. Further copies may be obtained from The Patent Office. Sales Branch, St Mary Cray, Orpington, Kent BR5 3RD. Printed by Multiplex techniques ltd, St Mary Cray, Kent, Con. 1/87